Space Technology Research Grants

Trajectory Design in a Combined Low-Thrust Multi-Body Environment

Completed Technology Project (2016 - 2020)

Project Introduction

Low-thrust propulsion (e.g. electric propulsion, solar sailing, etc.) is a promising new technology that may allow smaller, more efficient spacecraft to participate in space science and exploration. In order to undertake such missions, mission designers must obtain feasible initial solutions for trajectories that allow transfers to regions of interest within the bounds of the small amounts of thrust available to the spacecraft. Current design efforts leverage simplified gravity models and optimization theory to produce a specific trajectory for a single mission. Although this technique is capable of producing useful designs, it is numerically difficult to implement and can be incapable of responding to errors during flight operations. This investigation will explore motion propagated under more complex and accurate models to generate a roadmap of trajectory options in multi-body environments. To begin, the low-thrust, multi-body dynamics will be simplified and their basic behavior compared to familiar motion in multi-body environments. Questions of interest include: how will known periodic and quasi-periodic orbits change when low-thrust is added to the governing equations? What kinds of new motion will appear, and what kinds of motion will disappear? The application of Poincare maps will provide tools to investigate motion patterns throughout the space. Finally, the motion observed in this research will be applied to past and current low-thrust mission trajectories to demonstrate the validity and usefulness of the proposed methods; NASA software will be used for this analysis in conjunction with the excellent computational capabilities provide by the Multi-Body Dynamics Research Group at Purdue University. This research has several perceived benefits. In general, the knowledge and tools gained will assist mission design experts in their work to construct paths for low-thrust-equipped vehicles through interplanetary space, contributing to NASA's goal to pioneer the future in space exploration. The improved landscape of trajectory options produced by this research will allow rapid re-design of low-thrust trajectories, and will extend intuition about the types of motion that can be feasibly obtained by applying low-thrust. Ultimately, this research may provide the framework to plan future low-cost missions throughout the solar system.

Anticipated Benefits

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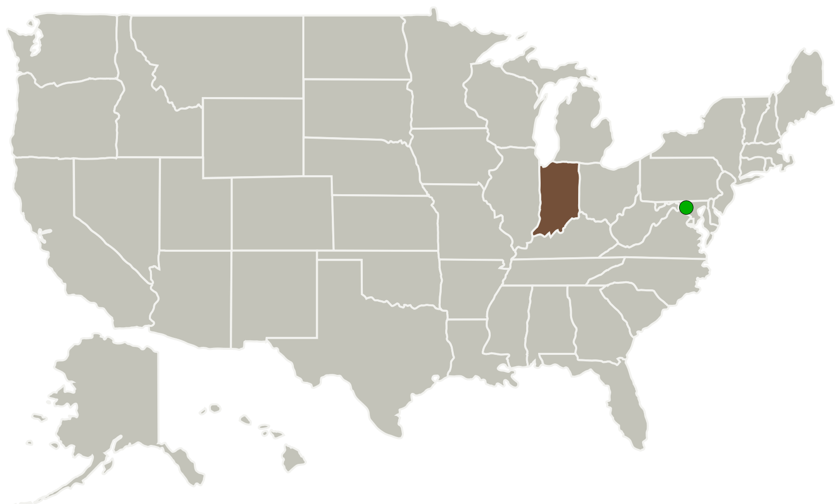
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Lead Organization	Academia	West Lafayette, Indiana
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Indiana

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Purdue University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

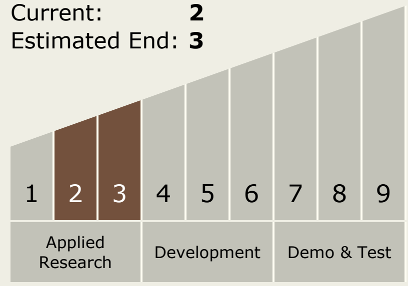
Kathleen M Howell

Co-Investigator:

Andrew D Cox

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  └ TX17.2 Navigation Technologies
    └ TX17.2.6 Rendezvous, Proximity Operations, and Capture Trajectory Design and Orbit Determination

Target Destinations

Mars, The Sun, Others Inside the Solar System